

# Nitrogen Oxides Emissions For Alberta 1978~1982



Environmental Protection Services  
Pollution Control Division





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NITROGEN OXIDES EMISSIONS

FOR ALBERTA

1978 - 1982

prepared by:

Alberta Environment  
Pollution Control Division  
Air Quality Control Branch

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Edmonton, Alberta




## EXECUTIVE SUMMARY

This report provides an inventory of nitrogen oxides emissions for Alberta from major industrial, transportation and combustion sources for the period 1978 to 1982. The nitrogen oxides emissions inventory is provided for source categories which include major industries, transportation, electric utilities, natural gas and heating fuel combustion, and forest fires. Emission estimates of natural gas processing, fertilizer plants, oil sands, petroleum refineries, cement manufacturing, chemical plants, and pulp and paper mills comprise the overall inventory of the major industrial source category. The natural gas processing industry category includes sweet and sour processing plants, reprocessing plants, field facilities, gathering systems, gas injection facilities, and transportation and distribution systems.

On the basis of the source categories outlined in the report, industry and transportation, which contributed about 42.1% and 35.2% respectively of the total nitrogen oxides emissions in 1982, were the major sources. The major industrial source was natural gas processing, which contributed about 33% of the total for 1982.





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# NITROGEN OXIDES EMISSIONS FOR ALBERTA

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## I INTRODUCTION

The Air Quality Control Branch of the Pollution Control Division of Alberta Environment carried out the task of updating the "Nitrogen Oxides Emissions for Alberta" publication compiled in December, 1980 by the Research Management Division of Alberta Environment.

Nitrogen oxides emissions inventories are an important part of any pollution control program. The information summarized in this report is useful for determining control strategies, developing regulations, locating air monitoring networks and determining the effectiveness of control programs. A high priority has been given to the control of industrial acid rain-causing pollutants in Alberta. To monitor the progress and future trends of the nitrogen oxides emissions, it is necessary to update the emission inventory on a regular basis.

This report provides the nitrogen oxides source and emissions inventory for Alberta for the period 1978 to 1982. Nitrogen oxides emissions are a major class of air pollutants released to the atmosphere by many industrial and transportation sources. The industrial emission data compiled in this report were obtained from manual stack survey results whenever possible. The natural gas processing industry emissions, however, are estimates based on fuel consumption data. Emission estimates for most of the other categories were made using annual fuel consumption and production statistics. These were multiplied by applicable emission factors provided by the U.S. Environmental Protection Agency or Environment Canada to give overall totals for the year. Deviations from this procedure are noted in the tables.

Nitrogen oxides emissions are expressed in terms of nitrogen dioxide (NO<sub>2</sub>) throughout this report.

## II. SUMMARY

A summary of the nitrogen oxides emissions by source category in Alberta covering the period 1978 to 1982 is provided in Table 1. The source categories consist of major industries, transportation, electric utilities, natural gas and heating fuel combustion, and forest fires. The percentage of nitrogen oxides emissions from the various source categories from 1978 through 1982 are listed in Table 2. Figure 1 shows that the industrial and transportation sectors, which contributed about 77% of the total emissions in 1982, were the major sources of nitrogen oxides emissions. The trend of nitrogen oxides emissions from each of the source categories is illustrated in Figure 2.

Table 3 presents a summary of the nitrogen oxides emissions of the major industrial sources. Emission estimates of natural gas processing, fertilizer plants, oil sands plants, cement manufacturing, chemical plants, petroleum refineries, and pulp and paper mills represent the industrial sources. Natural gas processing is the major contributor. Figure 3 provides a trend of the relative contributions of the various industries in Alberta for the period 1978 to 1982.



TABLE 1  
SUMMARY OF NITROGEN OXIDES  
EMISSIONS BY SOURCE CATEGORY  
(TONNES/YEAR)

Source	1978	1979	1980	1981	1982
1. Major Industrial Sources	134,650	137,787	141,564	143,377	148,735
2. Transportation	112,732	121,626	129,586	130,730	124,572
3. Electric Utilities	35,584	39,876	48,925	49,180	46,517
4. Natural Gas and Heating Fuel Combustion	16,806	18,985	24,424	22,389	21,984
5. Forest Fires	67	5,467	18,841	38,985	11,703
TOTAL	299,839	323,741	363,340	384,661	353,511

Note:

- The industrial source category includes emission estimates for the natural gas processing, fertilizer plants, oil sands plants, cement manufacturing, chemical plants, petroleum refineries and pulp and paper mills.
- The transportation source category includes emission estimates for passenger cars, commercial vehicles and railways.
- The electric utilities category includes emission estimates from all power plants in Alberta.
- The natural gas and heating fuel combustion category includes emission estimates from the residential, commercial and industrial sectors.
- The forest fire category is based on emission estimates for forested areas consumed by fire on productive and potentially productive land. Non-productive land consumed by forest fires is not considered in the estimates.

TABLE 2  
PERCENTAGE OF NITROGEN OXIDES  
EMISSIONS BY SOURCE CATEGORY FOR THE PERIOD 1978-1982

Source	1978	1979	1980	1981	1982
1. Major Industrial Sources	44.9	42.6	38.9	37.3	42.1
2. Transportation	37.6	37.6	35.7	34.0	35.2
3. Electric Utilities	11.9	12.3	13.5	12.8	13.2
4. Natural Gas and Heating Fuel Combustion	5.6	5.8	6.7	5.8	6.2
5. Forest Fires	0.0	1.7	5.2	10.1	3.3

**FIGURE 1. NITROGEN OXIDES EMISSIONS  
IN ALBERTA (1982)**

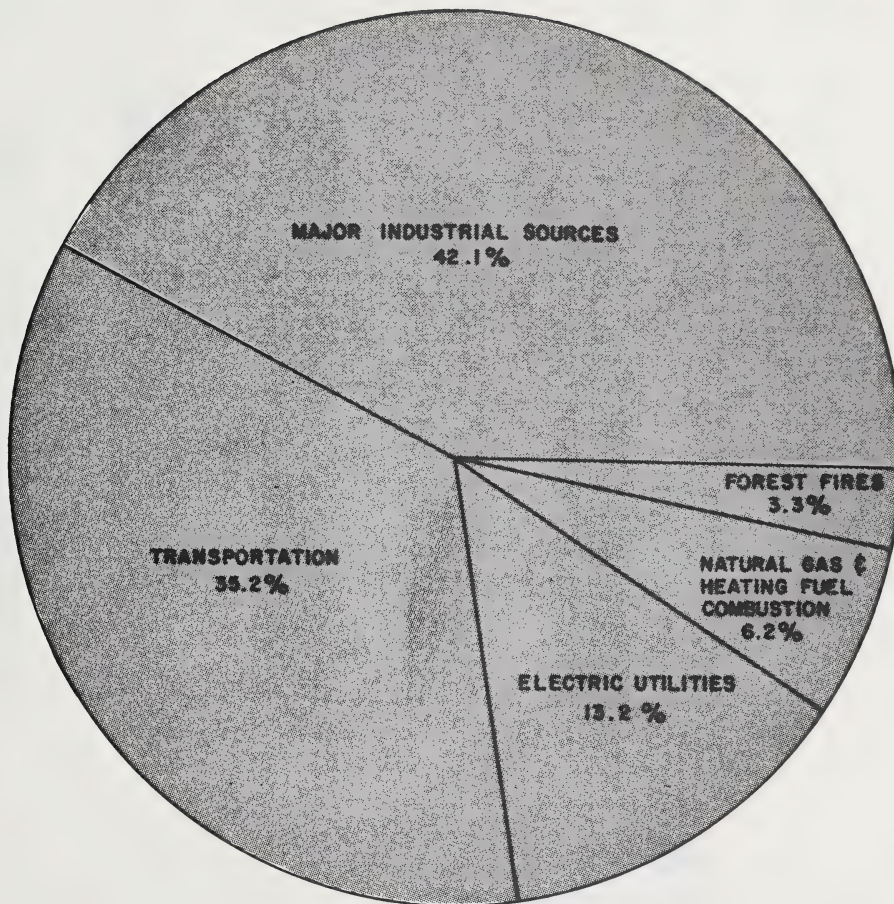
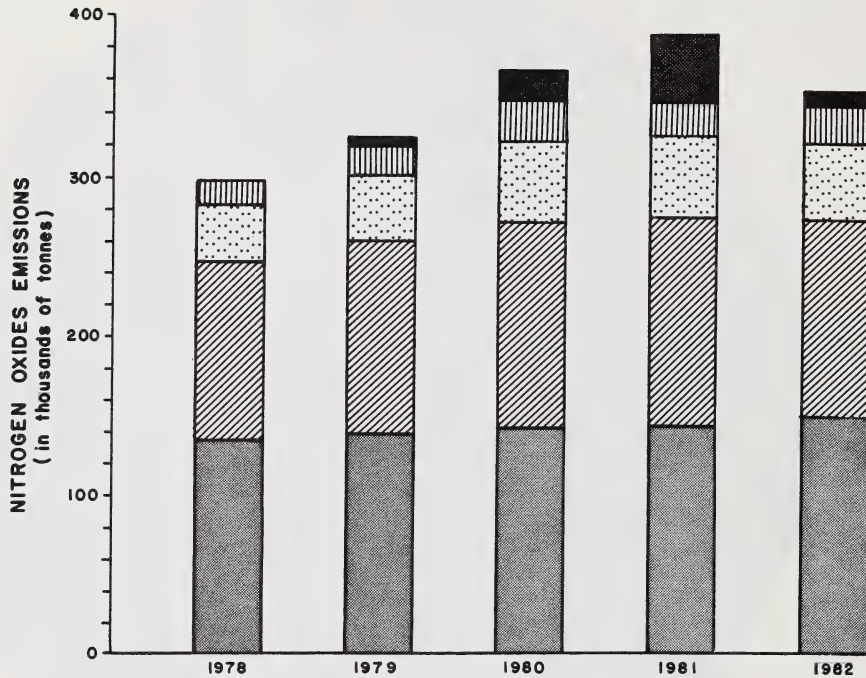




FIGURE 2. TREND OF NITROGEN OXIDES SOURCE AND EMISSION ESTIMATES FOR ALBERTA (1978-1982)



LEGEND






-  FOREST FIRES
-  NATURAL GAS & HEATING FUEL COMBUSTION
-  ELECTRICAL UTILITIES
-  TRANSPORTATION
-  MAJOR INDUSTRIAL SOURCES

TABLE 3

TOTAL NITROGEN OXIDES EMISSIONS (TONNES/YEAR)  
FROM INDUSTRIAL SOURCES IN ALBERTA 1978-1982<sup>a,b</sup>

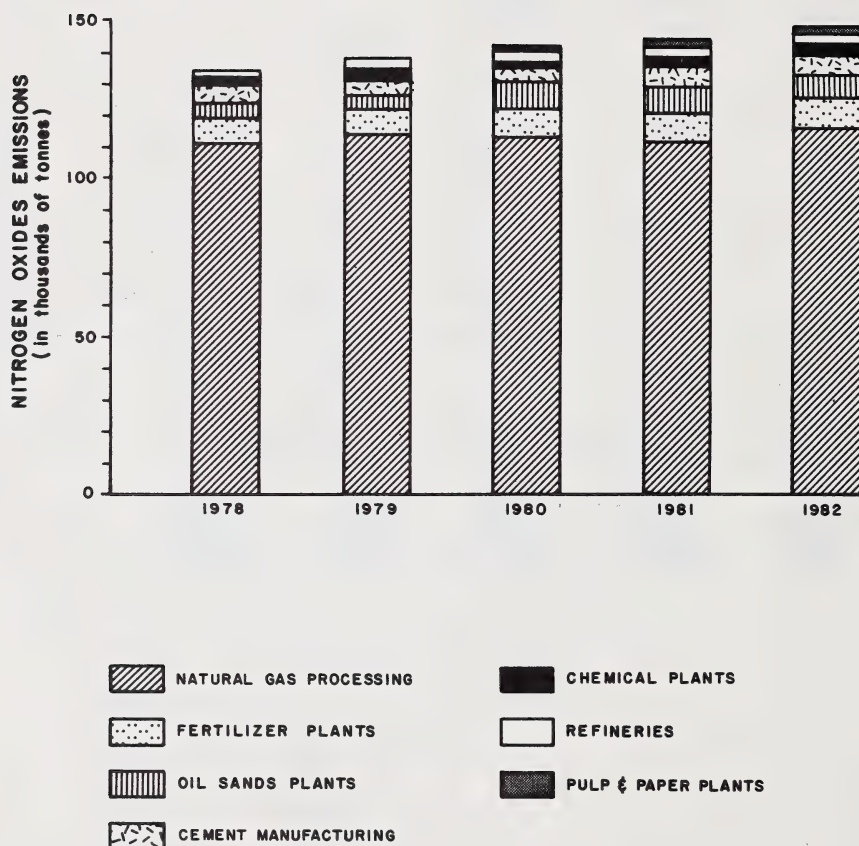
Industry	1978	1979	1980	1981	1982
Cement Manufacturing	4300	4800	5070	6620	6090
Fertilizer Plants	8248	8174	8783	7976	7249
Chemical Plants	3442	4423	2458	2728	4049
Refineries	1933	1949	1822	2292	2278
Natural Gas Processing	110,727	113,441	113,021	110,951	116,509
Oil Sands Plants	6000	5000	8700	9900	9500
Pulp & Paper Mills	N/A	N/A	1710	2910	3060
TOTAL	134,650	137,787	141,564	143,377	148,735

<sup>a</sup> Estimated as NO<sub>2</sub>

<sup>b</sup> Note that nitrogen oxides emission estimates from remaining industries are shown in Table 12.

N/A Not Available

FIGURE 3. TREND OF NITROGEN OXIDES EMISSIONS  
FROM MAJOR INDUSTRIES IN ALBERTA  
( 1978 - 1982 )





### III NITROGEN OXIDES EMISSIONS FROM MAJOR SOURCES

This section contains the data on nitrogen oxides emissions for the various industrial, transportation, electric utility, combustion and forest fire sources contributing to the emissions inventory in Alberta for the period 1978 to 1982. Tables 3 to 13 provide the breakdown on a year-to-year basis of the nitrogen oxides emissions for these sources.

TABLE 4

NITROGEN OXIDES EMISSIONS (TONNES/YEAR)  
FROM NATURAL GAS PROCESSING IN ALBERTA<sup>a,b</sup>

Source	1978	1979	1980	1981	1982
<b>1. Compressors (reciprocating)<sup>c</sup></b>					
Processing Plants:					
- sour gas	24099	24581	25232	24667	25673
- sweet gas	36857	37594	33495	32745	34079
Field	4181	4469	4371	4203	4458
Gathering Systems	29089	28910	32652	32678	34562
Transportation & Distribution	1693 <sup>d</sup>	2011	1698	1563	2003
Gas Injection	2338 <sup>d</sup>	2404	2618	2529	2543
Subtotal	98257	99969	100066	98385	103318
<b>2. Compressors (turbine)<sup>c</sup></b>					
Gathering Systems	130 <sup>d</sup>	129	146	146	154
Transportation & Distribution	1293 <sup>d</sup>	1536	1297	1193	1530
Reprocessing Plants	1562 <sup>d</sup>	1957	1739	1715	1592
Gas Injection	198 <sup>d</sup>	204	222	215	216
Subtotal	3183	3826	3404	3269	3492
<b>3. Heaters and Boilers<sup>c</sup></b>					
Processing Plants:					
- sour gas	5231	5336	5477	5354	5572
- sweet gas	1326	1352	1205	1178	1226
Field	2513	2686	2627	2527	2680
Reprocessing Plants	217	272	242	238	221
Subtotal	9287	9646	9551	9297	9699
<b>TOTAL</b>	<b>110727</b>	<b>113441</b>	<b>113021</b>	<b>110951</b>	<b>116509</b>

a Estimated as NO<sub>2</sub>.

b The inventory is based on fuel consumption data obtained from Alberta Gas Plant Statistics - E.R.C.B. Fuel usage fractions (percentage of fuel used for reciprocating engine and turbine type compressor, and heaters and boilers) obtained from Dr. M. Winning (Shell Canada Ltd., 1980) and M. Zelensky (Western Research, 1983).

c Emission factors were obtained from U.S. Environmental Protection Agency 1981.

Compressors (reciprocating) - 55400 kg/10<sup>6</sup> m<sup>3</sup>

Compressors (turbines) - 4700 kg/10<sup>6</sup> m<sup>3</sup>

Heaters and boilers - 3700 kg/10<sup>6</sup> m<sup>3</sup>

d Estimated through extrapolation from 1979-1982 data.

TABLE 5  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
OIL SANDS INDUSTRY IN ALBERTA <sup>a,b</sup>

Source	1978	1979	1980	1981	1982
Suncor	5500 <sup>c</sup>	4500 <sup>c</sup>	5400 <sup>c</sup>	4500 <sup>c</sup>	4200 <sup>c</sup>
Syncrude	N/A <sup>d</sup>	N/A <sup>d</sup>	2800 <sup>c</sup>	4900 <sup>c</sup>	4800 <sup>c</sup>
In-situ Heavy Oil Pilots <sup>e</sup>	500	500	500	500	500
TOTAL	6000	5000	8700	9900	9500

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Other types of oil sands plants produce heavy oil by means other than open pit mining (personal communication, Air Quality Control Branch, Alberta Environment, 1980).

<sup>c</sup> Estimated from stack surveys.

<sup>d</sup> Started operation in Summer 1978. Estimate not available. No manual stack surveys available.

<sup>e</sup> Estimated based upon an emission factor of  $1.32 \times 10^{-3} \text{ t/m}^3$  synthetic crude oil and 50% of licenced production.



TABLE 6  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
FERTILIZER PLANTS IN ALBERTA <sup>a,b,c,e</sup>

Plant (Location)	1978	1979	1980	1981	1982
Esso Chemical Canada (Redwater)	185	248	155	178	113
Cominco (Calgary)	389	374	337	438	391
Cominco (Carseland)	2897	2897	2820	3594	2631
C.I.L. (Carseland)	129	129	132	68	198
Western Co-op Ltd. <sup>d</sup> (Calgary)	838	838	1872	1026	376 <sup>f</sup>
Western Co-op Ltd. (Medicine Hat)	686	564	989	756	563
Sherritt Gordon Mines Ltd. (Fort Saskatchewan)	46	46	46	46	46
Canadian Fertilizer Ltd. (Medicine Hat)	3078	3078	2432	1870	2931
TOTAL	8248	8174	8783	7976	7249

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> The emission results reflect emissions mainly due to process production as opposed to utility usage purposes and constitute the best data available. Sources such as boiler stacks are not required to be monitored in all current licence conditions as emission rates from these sources are low in relation to the other sources within the plants (personal communication, L. Begoray, Air Quality Control Branch, Alberta Environment, 1983).

<sup>c</sup> Estimated from stack surveys and 330 operational days unless otherwise noted.

<sup>d</sup> 1980 estimate used for 1978-79 emission based on stack surveys and 330 operational days.

<sup>e</sup> 1980, 1981 estimates based on stack surveys and 300 operational days with the exception of Sherritt Gordon Mines Ltd.

<sup>f</sup> Extended plant shutdown during 1982.

TABLE 7

NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
CEMENT MANUFACTURING INDUSTRY IN ALBERTA <sup>a,b</sup>

Plant (Location)	1978	1979	1980	1981	1982
Canada Cement (Exshaw)	1900	2000	1700	3350	4360
Genstar Cement (Edmonton)	2400	2800	3370	3270	1730
TOTAL	4300	4800	5070	6620	6090

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Estimates are based on stack surveys and actual operational time during the year based on production data.

TABLE 8  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
REFINERIES IN ALBERTA<sup>a</sup>

Plant (Location)	1978	1979	1980	1981	1982
Esso <sup>b</sup> (Edmonton)	942	982	1202	1313	1143
Gulf <sup>b</sup> (Edmonton)	531	507	579	812	979
Texaco <sup>b</sup> (Edmonton)	460	460	41 <sup>e</sup>	167	156 <sup>e</sup>
Shell <sup>d</sup> (Bowden)	-	-	-	-	-
Husky Oil <sup>c</sup> (Lloydminster)	-	-	-	-	-
TOTAL	1933	1949	1822	2292	2278

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Estimated from stack surveys and usual operational time of 365 days.

<sup>c</sup> Largest single NO<sub>x</sub> source would be an incinerator--no estimates.

<sup>d</sup> Essentially less than 1 tonne per day of NO<sub>x</sub> emissions--no estimate of emissions.

<sup>e</sup> Based on 1 stack survey.

TABLE 9  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
CHEMICAL PLANTS IN ALBERTA<sup>a</sup>

Plant (Location)	1978	1979	1980	1981	1982
Alberta Gas Chemicals (Medicine Hat) 142		23	243	323	722 <sup>e,f</sup>
Celanese Canada (Edmonton)	2700 <sup>b</sup>	2700 <sup>b</sup>	515 <sup>b</sup>	705 <sup>b</sup>	415
Dow Chemical (Fort Saskatchewan)	300 <sup>b</sup>	1100 <sup>b</sup>	1100 <sup>b</sup>	1100 <sup>b</sup>	1798 <sup>d</sup>
Alberta Gas Ethylene (Joffre)	N/O	300 <sup>b</sup>	300 <sup>b</sup>	300 <sup>b</sup>	814 <sup>e</sup>
Subtotal	3142	4123	2158	2428	3749
Other Plants <sup>c</sup>	300	300	300	300	300
TOTAL	3442	4423	2458	2728	4049

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Estimates are based on stack surveys, licence requirements and 330 operational days. The values presented in the table are considered to be representative of overall NO<sub>x</sub> emissions from the plants. These computations were based on stack surveys conducted at the plants. Some small sources of NO<sub>x</sub> at the plants are not required to be surveyed. It is believed that their contributions to the overall NO<sub>x</sub> emissions would be insignificant (personal communications, W. Macdonald, Air Quality Control Branch, Alberta Environment, 1983).

<sup>c</sup> Estimated for unsurveyed plants by the Air Quality Control Branch of Alberta Environment.

<sup>d</sup> Based on maximum licence requirements and 330 operational days assuming full capacity.

<sup>e</sup> Estimate based on stack surveys, total production hours and average capacity.

<sup>f</sup> Reformer stack from plant #3 went into operation in 1982.



TABLE 10  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
PULP & PAPER MILLS IN ALBERTA <sup>a</sup>

Plant (Location)	1978	1979	1980	1981	1982
Procter and Gamble (Grande Prairie)	N/A	N/A	1710 <sup>b</sup>	2610 <sup>b</sup>	2760 <sup>b</sup>
St. Regis (Hinton)	N/A	N/A	N/A	N/A	300 <sup>c</sup>
TOTAL	-	-	1710	2610	3060

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Estimates are based on stack tests on the recovery boiler, power boiler and lime kiln, and 360 operating days per year.

<sup>c</sup> Estimates are based on stack tests on the main boiler and lime kiln.

N/A Not Available.

TABLE 11  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
POWER PLANTS IN ALBERTA<sup>a</sup>

Plant/Operator/Location	1978	1979	1980	1981	1982
Wabamun-Transalta (Lake Wabanum) <sup>b</sup>	4804	5518	6446	3901	5183
Sundance-Transalta (Lake Wabamun) <sup>b</sup>	17739	20527	26757	26486	27922
Rosssdale-Edm. Power (Edm.) <sup>c</sup>	2221	993	486	439	302
Cloverbar-Edm. Power (Edm.) <sup>c</sup>	1641	2333	2794	1393	815
Battle River-Alberta Power (Forestburg) <sup>b,d</sup>	2082	3343	4940	8953	6016
H.R. Milner-Alberta Power (Grande Cache) <sup>b,d</sup>	1124	979	885	1390	1305
Jasper-Alberta Power (Jasper)	549 <sup>e</sup>	447 <sup>e</sup>	487 <sup>e</sup>	488 <sup>e</sup>	172 <sup>b</sup>
Medicine Hat-City of M.H. (Medicine Hat)	996 <sup>e</sup>	1308 <sup>e</sup>	1702 <sup>e</sup>	1702 <sup>e</sup>	374 <sup>b</sup>
Subtotal	31156	35448	44497	44752	42089
Steam Plants <sup>f</sup>	328	328	328	328	328
Other Plants <sup>g</sup>	4100	4100	4100	4100	4100
TOTAL	35584	39876	48925	49180	46517

<sup>a</sup> Estimated as NO<sub>x</sub>.

<sup>b</sup> Industry capacity figures (based on time utilized and amount of operation time) and stack survey results are the bases of estimates.

<sup>c</sup> Edmonton Power provided detailed gross power output figures which allowed calculation of a capacity figure for yearly operations. Capacity figures and stack surveys were utilized for emission estimates.

<sup>d</sup> Industry operational time per year and percentage output factors were coupled with stack surveys for emission estimates.

<sup>e</sup> Estimates based on stack surveys and 300 operational days, assuming 100% capacity 24 hours per day.

<sup>f</sup> Only one stack survey available, operating approximately at 50% capacity; assumed linear relation to other steam plants.

<sup>g</sup> An estimate for smaller plants that run on diesel and natural gas. Estimate based on total megawatts produced and an emission factor from Environment Canada (1978).

TABLE 12  
NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
TRANSPORTATION SOURCES IN ALBERTA<sup>a</sup>

Source	1978	1979	1980	1981	1982
Commercial Vehicles <sup>c</sup>					
Light Duty	7425	8060	8413	8295	7416
Medium Duty	3703	4020	4196	3825	3553
Heavy Duty (gasoline)	3697	4013	4189	4190	4032
Heavy Duty (diesel)	54207	58841	61418	62692	61473
Subtotal	69032	74934	78216	79002	76474
Passenger Cars <sup>b</sup>	31819	34390	37650	38056	36007
Railways <sup>d</sup>	11881	12302	13720	13672	12091
TOTAL	112732	121626	129586	130730	124572

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Based on number of registered vehicles (Alberta Solicitor General, 1983); an average travelling distance of 18,520 km and composite emission factors of 1.81 g/km for 1978-1980; 1.73 g/km for 1981; and 1.57 g/km for 1982 (Research Management Division, 1983; Alberta Oxides of Nitrogen Emissions Forecast 1980 to 2000).

<sup>c</sup> Based on the following factors:

	<u>light duty</u>	<u>medium duty</u>	<u>heavy duty (gasoline)</u>	<u>heavy duty (diesel)</u>
% of total commercial vehicles	63.2	18.9	6.7	11.2
average driving distance (km)	15770	19780	21800	80520
composite emission factors (g/km)				
1978-1980	1.76	2.34	5.98	14.2
1981	1.70	2.09	5.86	14.2
1982	1.55	1.98	5.76	14.2

Sources: as per footnote b

<sup>d</sup> Based on fuel oil consumption data (Alberta Treasury 1980, 1983) and an emission factor from Environment Canada (1978) of 44 kg/1000 litres.

TABLE 13

NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
NATURAL GAS AND HEATING FUEL COMBUSTION SOURCES IN ALBERTA<sup>a</sup>

Source	1978	1979	1980	1981	1982
Residential	3121 <sup>b</sup>	4121 <sup>b</sup>	3723 <sup>c</sup>	3870 <sup>c</sup>	4187 <sup>c</sup>
Commercial	4083 <sup>b</sup>	4292 <sup>b</sup>	4641 <sup>d</sup>	4284 <sup>d</sup>	3927 <sup>d</sup>
Industrial	9602 <sup>b</sup>	10572 <sup>b</sup>	16060 <sup>e</sup>	14235 <sup>e</sup>	13870 <sup>e</sup>
TOTAL	16806	18985	24424	22389	21984

<sup>a</sup> Estimated as NO<sub>2</sub>.

<sup>b</sup> Based on data provided in "Nitrogen Oxides Emissions for Alberta 1976 to 1979". Prepared for Alberta Environment, Research Management Division, RMD Report 80/3.

<sup>c</sup> Based on "Alberta Oxides of Nitrogen Emissions Forecast 1980 to 2000", Research Management Division, RMD Report 83/26 in which natural gas requirements were obtained from Alberta Electrical Utility Planning Council. The emission factors in these estimates were obtained from EPA (1981) and are as follows:

34 ng/J - gas fired  
32 ng/J - propane fired  
58 ng/J - oil fired

<sup>d</sup> Based on "Alberta Oxides of Nitrogen Emission Forecast 1980 to 2000", Research Management Division, RMD Report 83/26. The emission factor used in these estimates, obtained from EPA (1981), is as follows: 51 ng/J - gas fired.

<sup>e</sup> Based on "Alberta Oxides of Nitrogen Emission Forecast 1980 to 2000", Research Management Division, RMD Report 83/26 in which industrial gas requirements were obtained from ERCB, coupled with an emission factor of 257 ng NO<sub>2</sub>/J of natural gas input, EPA (1981).



TABLE 14  
TOTAL NITROGEN OXIDES EMISSIONS (TONNES/YEAR) FROM  
FOREST FIRES IN ALBERTA<sup>a,b,c,d</sup>

Source	1978	1979	1980	1981	1982
Forest Fires	70	5470	18840	38990	11700
TOTAL	70	5470	18840	38990	11700

<sup>a</sup> Areas consumed by fire of greater than 12 hectares were included in these estimates.

<sup>b</sup> Forest fire statistics were obtained from the Alberta Forest Service Division of Alberta Energy and Natural Resources.

<sup>c</sup> Nitrogen oxides emissions were estimated based on 100% of the area consumed by fire on productive land and 50% of the area consumed by fire on potentially productive land. Non-productive land consumed by forest fire was not considered in estimating nitrogen oxides emissions.

<sup>d</sup> Emission factors utilized were as follows:  
44.8 kg of NO<sub>x</sub>/hectare consumed for conifers  
53.8 kg NO<sub>x</sub>/hectare consumed for hardwood  
(Saskatchewan Environment 1982).

V. REFERENCES CITED

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